

The DarkSide-G2 experiment at LNGS

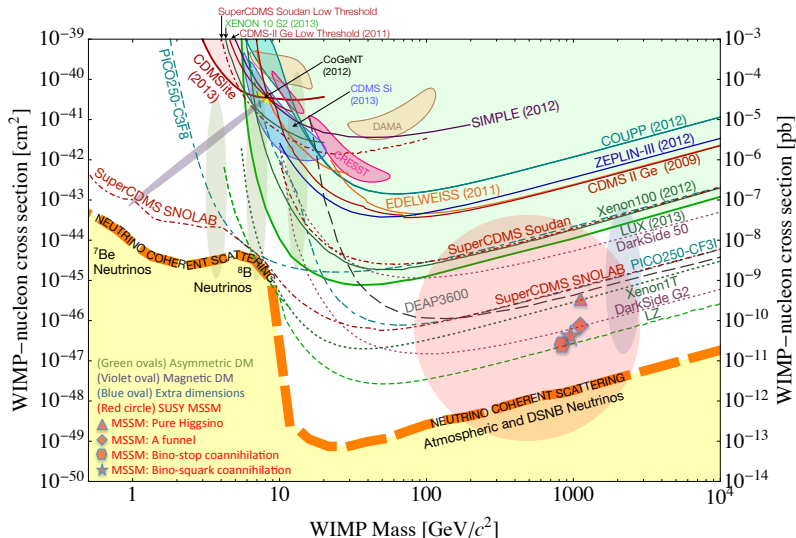
for the DarkSide collaboration
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By S. Walker

DarkSide-G2 sensitivity in a Dark Matter race

Achieve sensitivity of $\sigma \sim 2 \times 10^{-47} \text{cm}^2$ in 18 ton-year.



The DarkSide Collaboration



is supported by NSF, DOE, INFN and other agencies

Princeton University, USA (x2)
University of Chicago, USA
University of Houston, USA
University of Massachusetts, USA
University of Hawaii, USA
Temple University, USA
Augustana College, USA
Fermilab, USA
LLNL, USA
LANL, USA
BNL, USA
PNLA, USA
SLAC, USA
UC Davis, USA
BHSU, USA
UCLA, USA
Virginia Tech, USA

INFN LNGS, IT
Gran Sasso Science Institute, IT
INFN Università degli Studi Genova, IT
INFN Università degli Studi Milano, IT
INFN Università degli Studi Napoli, IT
INFN Università degli Studi Perugia, IT
INFN Università degli Studi Roma 3, IT
Joint Institute for Nuclear Research, RU
SINP, Lomonosov Moscow SU, RU
IPHC, Université de Strasbourg, CNRS/IN2P3, FR
APC, Université Paris Diderot, FR
Jagiellonian University, PL
NRC Kurchatov Institute, RU
St. Petersburg NPI, RU
INR, UA
IHEP, CN

The DarkSide phased program at LNGS

Currently operating DarkSide-50 (see talk of L.Grandi)

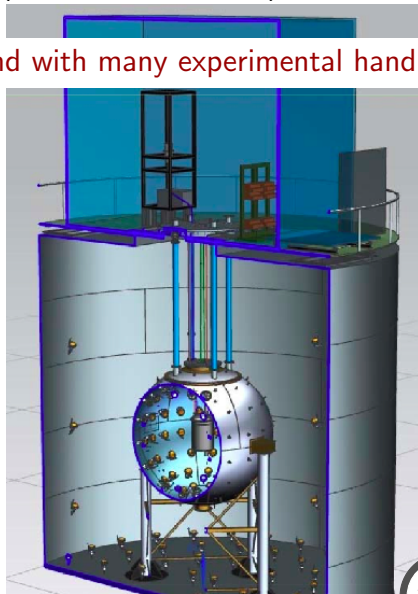
Understand&fight the background with many experimental handles

Radon-free clean room

μ and cosmogenic neutron veto

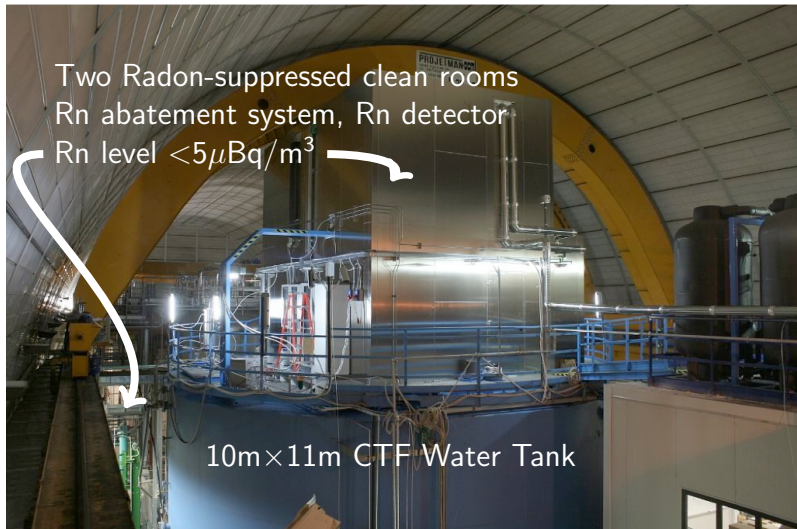
Radiogenic neutron veto

Dual-phase LAr TPC



The DarkSide-G2 at LNGS - Existing Facilities

Many facilities sized and built to house DarkSide-G2.

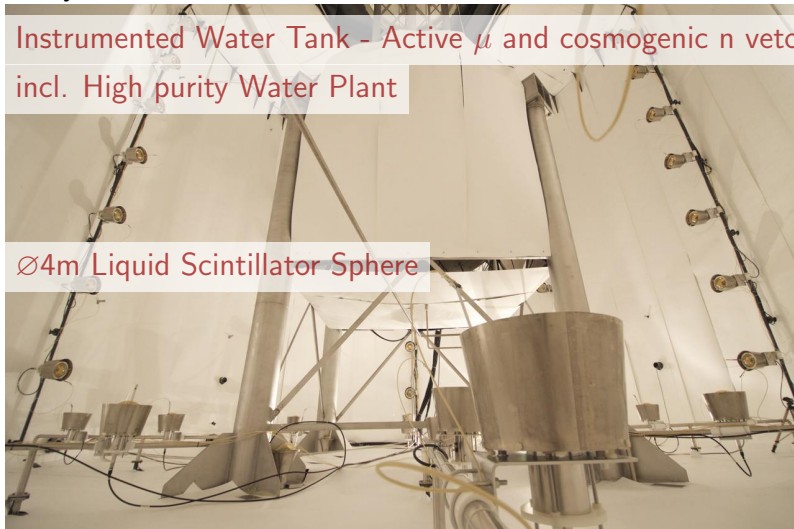


The DarkSide-G2 at LNGS - Existing facilities

Many facilities sized and built to house DarkSide-G2.

Instrumented Water Tank - Active μ and cosmogenic n veto
incl. High purity Water Plant

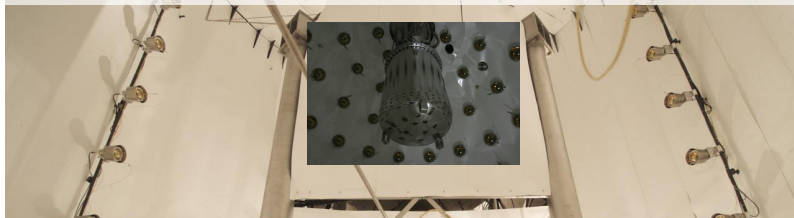
Ø4m Liquid Scintillator Sphere



The DarkSide-G2 at LNGS - Existing facilities

Many facilities sized and built to house DarkSide-G2.

Instrumented Water Tank - Active μ and cosmogenic n veto



Instrumented LS Sphere - Active radiogenic n and γ veto including Boron-loaded scintillator storage, purification plants



LSV Light yield as expected $\sim 0.5\text{PE/keV}$.

Ongoing study of TPC-LSV and TPC-LSV-MV coincidence events

The DarkSide-G2 at LNGS - New facilities

Scale and improve inner detector, cryogenic/purification systems.
Build ULAr recovery system, LSV+TPC calibration system.

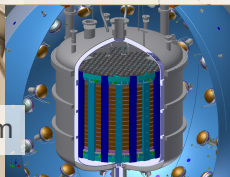
Calibration system

"Articulated Arm"

Recovery in liquid form

"Drain system"

Preliminary design



Cryogenic system

Purification system

(see talk Y.Suvorov)

$\tau(\text{DS-50}) \gtrsim 5\text{ms}$

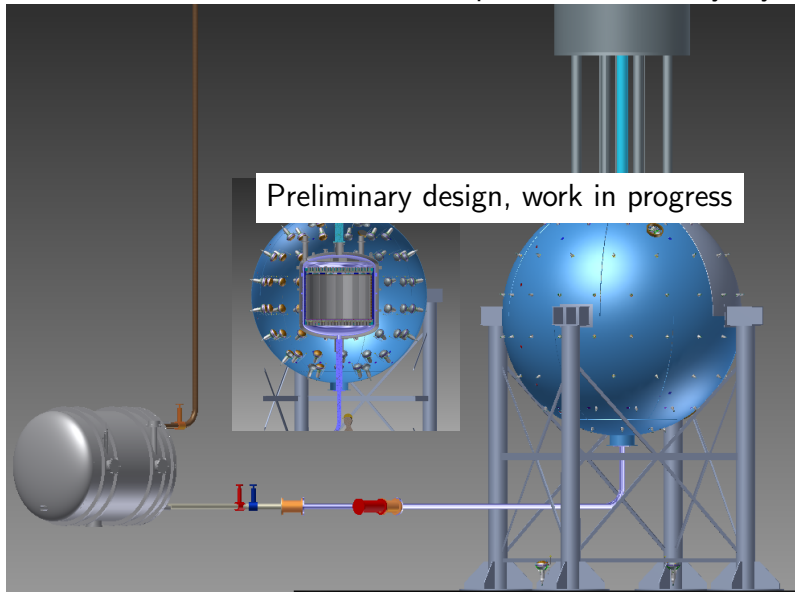
Rn level $< 1\mu\text{Bg/kg}$

Active 3.8 tonnes of ULAr

G2 UAr extraction (see talk H.Back)

The DarkSide-G2 recovery system

Fast transfer of ULAr from TPC to pre-cooled recovery cryostat.



The DarkSide calibration system

"Articulated arm" source deployment system for DS-50 and DS-G2

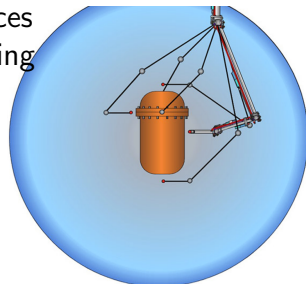
Calibration of both LSV and TPC

Needs to accomodate DarkSide-G2 TPC

Flexible deployment system for various sources

Cameras for monitoring and source positioning

Conceptual design



Gaseous ER source deployment integrated in the gas system.

^{83m}Kr , ^{39}Ar , ^{37}Ar

The DarkSide-G2 inner detector

Feasible and scaled DarkSide-50.

Goal: high light yield and radio/chemical-purity.

Material selection ongoing

Stainless steel (cryostat, PMT support)

Copper field cage

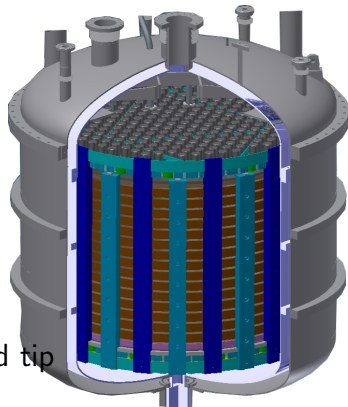
PTFE for segmented reflective cylinder

Fused silica for windows/diving bell

Upgrade of WLS evaporator

HVFT design ready=compact with flared tip
(Tested up to 200kV)

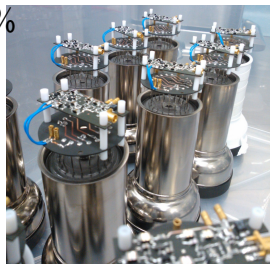
G2 requirement with contingency = 75kV



DarkSide-G2 TPC photon detection

Baseline: 3" PMTs improved R11065 series with Cold Amplifier.
R11065-20 are ultra radiopure and $QE > 30\%$
but they are unstable at LAr temp.

Radio-pure cold amplifiers are crucial
for stable R11065-10 operation in DS-50
lower HV bias, higher dynamics



Intensive R&D to achieve **STABLE** operation

improve 3" R11065: work with Hamamatsu, testing ongoing

scale to 4" PMT: work with Hamamatsu, prototype testing soon

develop 3"-4" hybrid photosensor: ongoing, prototype during 2014

DarkSide-G2 Background Budget

For 18 ton-year exposure in the ROI (threshold $\sim 35\text{keV}_r$):
Dominant electronic recoil background is due to $^{39}\text{Ar} \sim \mathcal{O}(10^8)$.
(PMTs, cryostat, ^{222}Rn and daughters $\lesssim \mathcal{O}(10^6)$)
It is crucial to demonstrate rejection via Pulse Shape discrimination (together with S2/S1, 3D).

Eq.	Exposure	Rejection	Calibration Data
	0.28ton-year	PSD	DS-50 AAr (SCENE NR data)
	Planned >0.28ton-year	PSD	DS-50 AAr (in situ NR data)
	Considering >18ton-year	PSD	DS-50 Spike ^{39}Ar

DarkSide-G2 Background Budget

For 18 ton-year exposure in the ROI (threshold $\sim 35\text{keV}_r$):
Cosmogenic/Radiogenic neutron background is sub-dominant.
(PMTs, cryostat, muon-induced $\sim \mathcal{O}(10^2)$)
It is crucial to calibrate efficiencies of the active vetos.

Calibrate neutron veto efficiency using LSV-TPC coincidence events for point calibration sources and extrapolate it to distributed sources using Monte Carlo simulations.
Use tagged cosmogenic neutrons in LSV-TPC or MV-TPC in combination with Monte Carlo simulations.

Summary

The DarkSide-G2 timescale:

Program is following "G2 down-selection" process.

If funded, commissioning of the detector is planned for FY17.

DarkSide-50 is a key to DarkSide-G2:

Successful integration of Borexino facilities and expertise in radio-pure liquid scintillator and water deployment.

On-the-track schedule.

Performance and background budget is used to reliably infer G2 sensitivity and to identify and mitigate risk factors.

Existing facilities will enable faster deployment of the G2 system.

Use experience gained to scale and improve.

Thank you